# Human Engineering Process
# Process Overview

DD 21/ONR

SC-21 S&T Manning Affordability Initiative

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**DISCLAIMER**

This information constitutes a living document, and as such it is subject to change. It is believed that the overall, global process outlined here is valid. The details and descriptions of sub-steps of the process and supporting tools, however, may change over the course of the SC-21 S&T Manning Affordability Initiative. The initiative is focusing on developing systems to support operators and designers, and lessons learned will continually be assessed and reflected in this document.

**PROCESS OVERVIEW**

> Human Engineering: The application of human performance principles, models, measurements, and techniques to systems design. The goal of human engineering is to optimize systems performance by taking human physical and cognitive capabilities and limitations into consideration during design.
>
> DoD Directive 5000.53 (1988)

This document presents an overview of the human engineering process defined as part of the SC-21 S&T Manning Affordability Initiative (S&T). This process was created with two goals, the first of which was to define a generalizable process for human engineering that is compatible with systems engineering practices. The second goal was to define a process that can be used as a roadmap for identifying and (where required) developing tools and capabilities for the S&T project's Human-Centered Design Environment (HCDE).

As shown in Figure 1, the human engineering (HE) process is broken into six high-level steps – Mission Analysis, Requirements Analysis, Function Analysis, Function Allocation, Design, and Verification. The division of this process into different steps was based on pre-existing cycles of iteration and definable transitional products. The process is designed to be applied throughout the system development life cycle (concept definition, system design, subsystem design); the nature and detail of the activities performed in the process will therefore change as a function of the current life cycle step. The process is also intended to be iterative in nature and support concurrent design paths. A continual pattern of trade-off analysis and evaluation has been included.

Some of these sub-steps are specific to human engineering, but others are more general in nature and may cross into other disciplines or may be seen as system engineering process steps. Steps in this latter category may not even be performed by human engineers or with the intent to "do" human engineering, but their outputs typically include information or other products that drive decisions or are otherwise needed within the human engineering discipline.

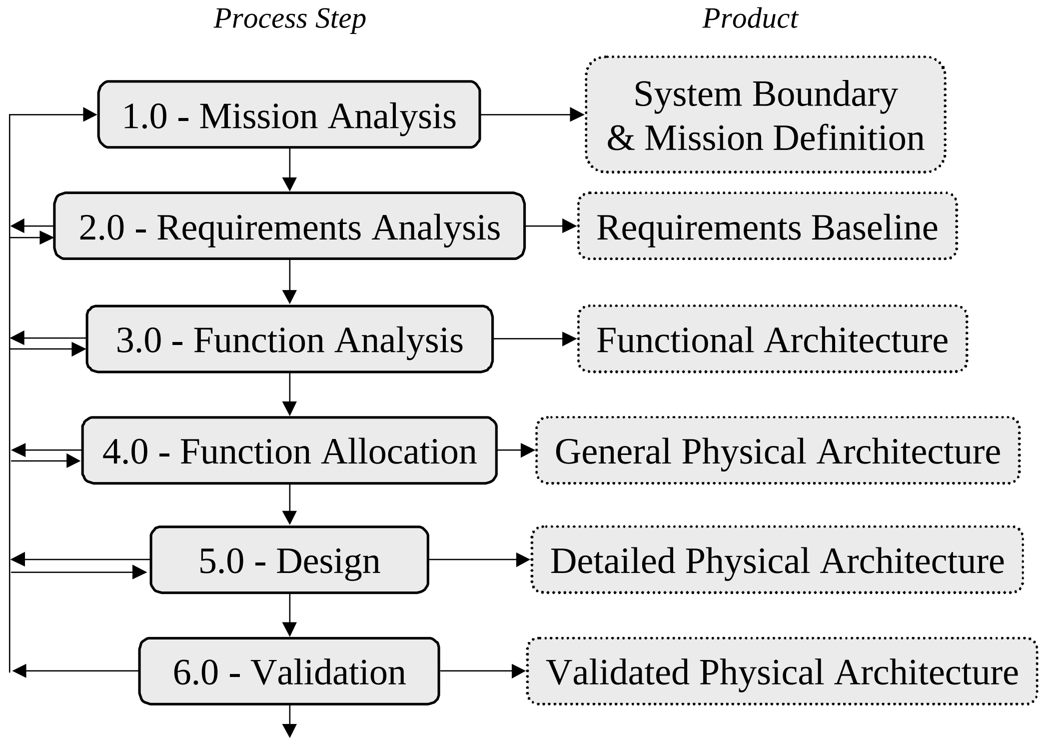


Figure 1. Top-Level Diagram of Human Engineering Process.

## 1.0 - MISSION ANALYSIS

Determine overall purposes or objectives and capabilities of the system and the environment in which the system must operate. Determine what basic functions the system is intended to perform. Identify or create mission scenarios. Focus in this stage is on the definition of the system boundaries, treating the system as a "black box" and defining inputs, outputs, environment, and other constraints.

## 2.0 - REQUIREMENTS ANALYSIS

Identify the characteristics of the system necessary to meet mission requirements. Determine the intended users (and maintainers) of the system. Identify and define the activity-related needs of users. Assess the feasibility and internal compatibility of the system requirements. Define the system's measures of effectiveness and measure of performance and the mission, human, and job / task requirements. Define the Human Role Strategy and manning, training, and cost guidelines.

## 3.0 - FUNCTION ANALYSIS

Define the system's functional architecture – the sequence of operations or events to turn inputs into desired outputs – and compare the potential alternatives. Although the system may be broken into functions, tasks, and subtasks to be performed, no allocation to particular system components takes place. This stage and the three following stages may be initially performed at a high system level with little function decomposition, but these stages must be reiterated at a level of greater detail as the design progresses.

## 4.0 - FUNCTION ALLOCATION

Distribute the defined functions between available resources (humans, hardware, software or combinations). The allocation of some functions will be mandatory and predetermined by constraints established in the Mission Analysis or Requirements Analysis stages of design. Allocation should also be determined by comparison of performance between humans, hardware, and software; cost factors; and affective and cognitive support for the operators. Allocation decisions should be made so as to maximize total system performance and effectiveness. Allocation of a function may require redefinition of its component subfunctions. Function allocation will also be guided by what pieces of information and decisions are required to initiate, sustain, and otherwise support the functions. The designer must determine how decisions affect or alter the system performance of the system itself. Allocation may be done in static terms or it may be dynamic, with functions changing their allocation at different stages of the system. The system must be defined in terms of component functions, tasks, and subtasks, including the flow of information and the allocation of the functions, tasks, and subtasks to individual system components.

### 4.1 – Mandatory Function Allocations

The first functions and decisions to be allocated must be those having specific allocations mandated by system requirements, the Human Role Strategy, or other factors. The Human Role Strategy will require that some functions or decisions be performed or made by humans within the system. Some functions or decisions will be required to be performed or made by hardware or software components of the system or by humans with the assistance of other system components in order to meet system requirements. The allocation of these functions and decisions may then logically require that other functions or decisions be allocated to a specific portion of the system.

### 4.2 – Create Alternate Allocations of Remaining Functions

Identify potential allocations for functions not yet allocated. Begin by assessing the capabilities and limitations of hardware and software technology as well as humans. Allocations may be made to hardware, software, humans, or combinations. Allocation may be static or dynamic, changing with operational conditions, workloads, or mission priorities. Allocation of mission-critical functions during the primary mission phase should take priority, followed by other primary mission functions and functions from other mission phases. Allocation options should be made based on component and system performance and a variety of other criteria.

### 4.3 – Select Optimal Function Allocation

Based on a qualitative comparison of system design factors (SDFs), select an optimal allocation of functions from the candidate allocations.

### 4.4 – Verify Allocation Compliance with System Requirements

Compare the selected allocation of functions to the system requirements, including mission requirements, human requirements, job / task requirements, and other MOE's and MOP's.

## 5.0 - DESIGN

Define a time-based description of the allocated functional architecture of the system. Particular attention must be paid to interactions between tasks and between humans and equipment and the flow of information and objects between components of the system as currently allocated. Analyze this architecture and redefine functions and tasks as necessary to meet mission requirements. Determine whether or not the specified levels of activity (physical, mental, etc.) of both humans and equipment can be met with the resources currently available (or projected to be available). Once the functional architecture meets mission and system requirements, operator interfaces may be specified and designed. Changes made to the functional architecture at this stage will require a return to earlier stages to ensure that all system / mission requirements will be met.

**5.1 – Task Design and Analysis**
Based on the functions allocated to humans, develop the human tasks required to ensure successful completion of the function. Task development is based on a decision analysis approach. This produces a depiction of the task in terms of the cues to alert the human that a decision / action needs to be taken, the decisions / action to be made, the information required to support the decision, and mechanisms to implement the results of the decision / action. The critical characteristics and interactions are also articulated.

**5.2 – Design Human Interfaces**
Design the interfaces between humans and hardware, software, and other humans. Both physical and procedural interfaces should be considered. Develop individual and team interfaces.

**5.3 – Estimate Performance, Workload, and Manning Levels**
Estimate the physical (perceptual, psychomotor, physiological, etc.) and cognitive workload levels of individuals and teams within the system. Define workload stressors and their effects on human performance, operator coping strategies, and the effects of task neglect / delay. Workload and the resultant manning and training requirements are to be optimized to meet required performance levels.

## 6.0 - VERIFICATION

Assess the potential performance of the system with respect to its ability to achieve its required levels of operation (MOE's, MOP's). Verification may be carried out either during conceptual stages using analytical or executable system models or after a physical prototype or mock-up has been constructed using human-in-the-loop simulations. Verification of some system components may be concurrent with design of other components. Verification is performed within the context of design, not production. If the system under design is unable to achieve the required levels of performance and operation, then either the requirements must be altered or the design must be improved through re-allocation of functions or selection of an alternate design.

## HUMAN ENGINEERING AND SYSTEMS ENGINEERING

Traditional problems in human engineering and the application of human factors principles in general have included lack of compatibility with an overall systems engineering process and the lack of readily observable inputs to the overall design process.

One of the causes of these traditional problems has been a difference in terminology between the systems engineering and human engineering disciplines. When possible, this process uses terminology equivalent with that found in the systems engineering domain and provides definitions of human engineering terms that may not be familiar to those with a systems engineering background. It is hoped that the use of terminology common to the systems engineer coupled with definitions of key human engineering terms will enable the systems engineer to visualize how human engineering fits within an overall systems view. It is also hoped that it will enable the human engineer to see how human engineering and human factors principles and products interact with systems engineering.

The human engineering process presented here was designed to be compatible with the process outlined in IEEE 1220, Standard for the Application and Management of the Systems Engineering Process. The two processes have a shared terminology, and the steps of the processes themselves have been designed to be parallel, as shown in Figure 2. The green blocks represent portions of the systems engineering process, and the yellow blocks designate the human engineering activities that take place within systems engineering.

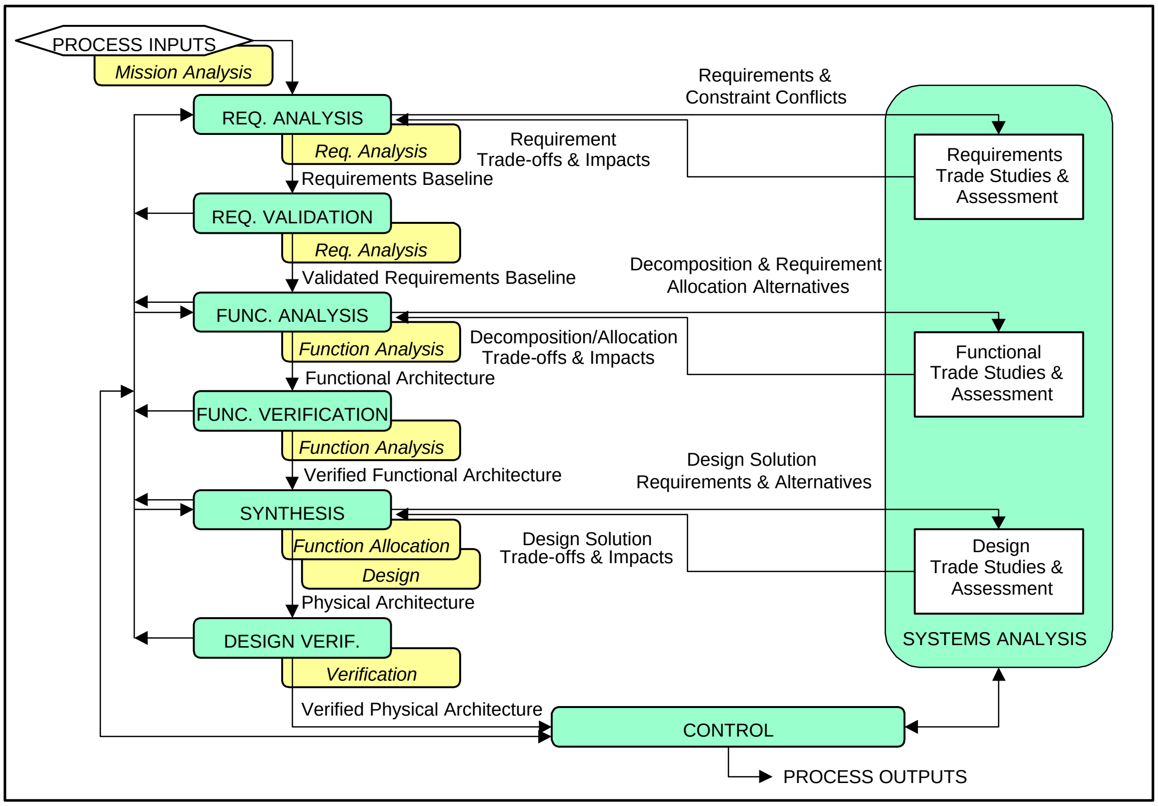


Figure 2. Human Engineering Process and Systems Engineering Process of IEEE 1220.